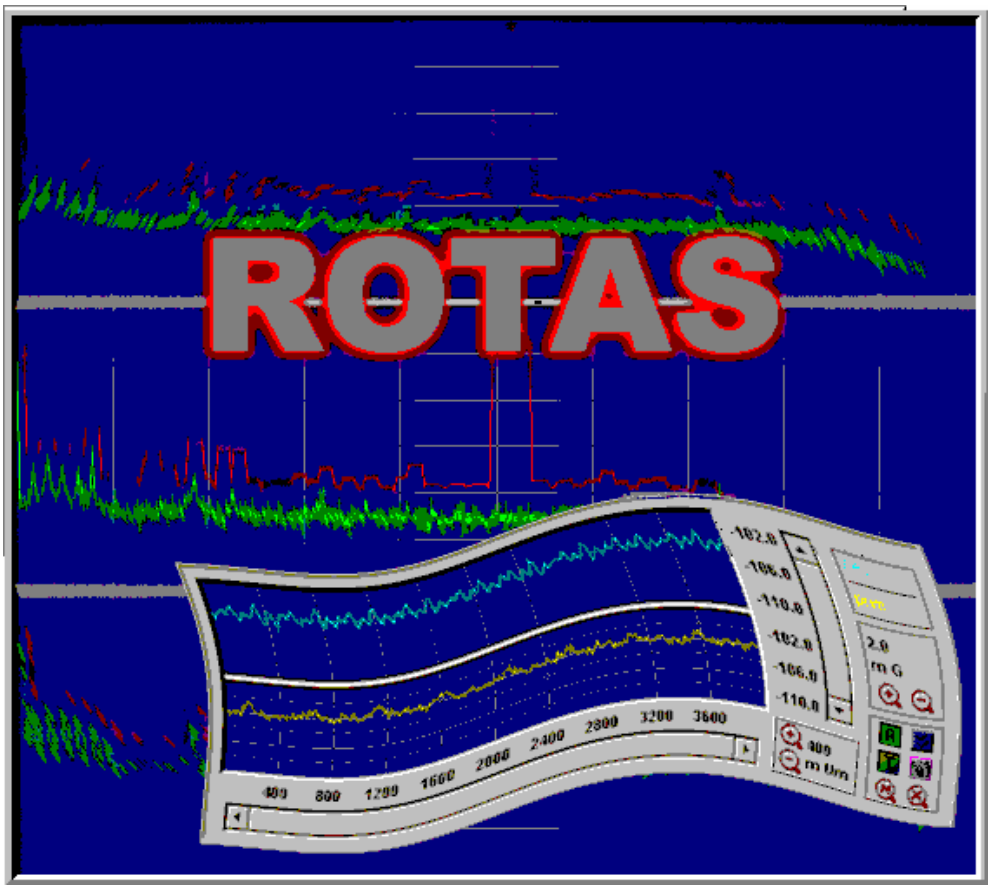
User Manual

RotasPro bearing test system

Discom GmbH, Göttingen

Translated October 2001 by Mark Roberts



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Introduction

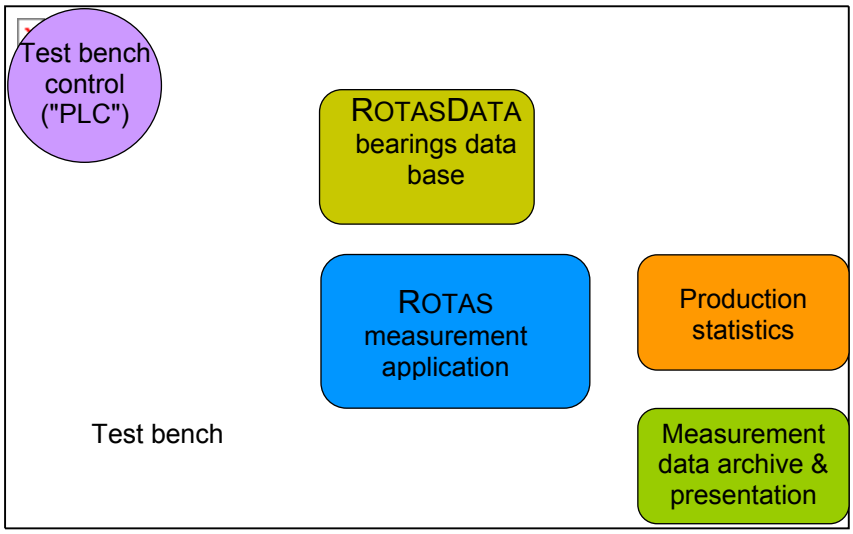
The Rotas-System

The Rotas acoustic measurement system is made up of a number of components that represent not only the program itself but also the peripherals of measurement, value computation and storage.

The central component, with which this manual is mainly concerned, is the measurement and analysis program *RotasPro*.

RotasPro can be parameterised using a test procedure data base which stores mechanical and acoustical details of the parts to be measured. Other data bases contain tables for archiving measurement results for every tested part, and the production counts local to every measurement stand. A overall measurement value archive stores every detail of every measurement at every stand. A presentation component is supplied for viewing and interpreting this archive that can be configured freely.

The system is organised in the following way:



The components of the Rotas-System

The measurement program is run on a computer equipped with signal processor cards. It consists of several modules that can be executed in parallel on these processors. AD converters and angular momentum decoders are located on the cards and are used to input the noise and rotational speed from the measurement stand. Every card can record up to two rotational speeds and four acoustic channels.

The signal processors host the computations (e.g. order analysis), while the application on the PC displays and evaluates the results. The program thereby associates the measurements with the measured part's type and other information (serial number etc.), which are supplied by the measurement stand, as well as with the rules and limit values stored for that type in the test procedure data base. Results are output in human readable form and forwarded to the measurement stand control in coded form.

The program's modular structure

The ROTAS-application is made up of a large number of modules. Every module represents a particular processing step or a typical task. It begins with modules for AD conversion, filters and order analysis for every channel and continues over modules for spectral analysis, time domain signal analysis and short period spectra, to evaluation modules, viewing modules and communication modules. Other modules permit storing measured data, controlling unusual periphery or exporting data to formats like Excel.

Usually a module will contain auxiliary modules (sub-modules), for instance for transferring data or converting formats. All modules in a RotasPro or ComPass application are organised in a tree. Every module with the exception of the topmost module has a parent module, and every module has any number (including zero) of child- or sub-modules. The tree is referred to as the system configuration.

The module tree is displayed in the tree view (or system configuration window). Every module, or, to be precise, every instance of every module, is represented by an icon and an instance name. Often but not always the icon gives an indication of the module type. A "Wire"-module for instance is usually represented by an icon of a socket or a plug. If a module has child modules, a small plus sign is situated to the left of the module's icon. When you click the plus sign, the child modules become visible and the plus becomes a minus. Click the minus sign to hide the child modules.

In order to bring order to the system configuration, container modules are included who's sole purpose is to be parent to a group of modules that perform a particular task together.

Should you wish to open the system configuration window after it has been closed, you can do so by clicking "New" in the pulldown menu "File" or by clicking the associated button in the button bar.

Fundamentals of operation

Since the complete functionality in a RotasPro application is situated in the modules, the user can also operate the program via the modules. For reasons of simplicity though, the most important features can also be reached from the menu and toolbars.

Double click on the name or the icon of a module in the system tree in order to open its dialog. If a module represents a window (e.g. curve view or report window), double clicking will instead open that window, unless it is already open. If such a module also houses a dialog, you can open the dialog by double clicking with the right hand mouse button.

Certain modules (e.g. container modules or "Wire" modules) don't need a dialog, as there are no values to set up.

For the most important functions that you need every day, menu items and toolbar buttons have been supplied. You usually don't need to search for modules in the tree at all. On top of that it is possible to set up several sets of user permissions, so that normal users can only access a subset of menus and buttons and cannot open the system configuration tree.

Rotation synchronous order analysis

The measurement system ROTAS is designed for the analysis of rotating systems like cogwheels, bearings or gear boxes. The analysis can be extended to systems that are driven by rotating systems. Our measurement quality is mainly built on rotation synchronous order analysis. In simple spectral analysis fixed sample rates (often 44.1 kHz) and fixed FFT-lengths (e.g. 1024 samples) are used to compute the spectra. By averaging the results it is possible to extract frequency components constantly embedded in the measured sound. When analysing a rotating system this procedure would enhance the rotational frequency and it's harmonics. (The sample rate needs to be more than twice the rotational frequency.)

In rotation synchronous order analysis of a rotating system we instead choose sample rate and FFT-length in such a way that the FFT blocks consist of exactly one rotation (or a whole number of rotations). Supposing a part rotates at 50 Hz and an FFT-length of 512 samples is desired, then $50 \cdot 512$ samples need to be taken per second, which corresponds to a sample frequency of 25,6 kHz. By averaging these rotationally synchronous blocks, all frequencies are enhanced that are synchronous to the rotational speed or it's harmonics, while background noise is suppressed. If an apparatus has several parts that run at several frequencies, then the noise signals of the parts can be separated by applying a rotation synchronous order analysis at each of the frequencies.

RotasPro rescans the signal synchronously using the signal processors. First the signal is split into a number of parallel channels. In each of these channels the rescan is performed synchronous to a particular part of the rotating system. The resulting data streams are referred to as synchronous channels. The noise from the various parts of the system has been divided into these channels. In addition the original signal, now called the mix channel, is kept for future computation.

Order synchronous analysis is an exact form of order analysis. The revolution frequency in a synchronous channel is the first order of that channel. A frequency twice as large is the second order, five times the revolution frequency is the fifth order. The order spectrum does not represent absolute frequencies (as in spectral analysis), it represents frequencies relative to the revolution frequency of the synchronous channel. Interpreting the results of an order analysis is simple because it correlates with the rotation of the part to be measured.

RotasPro and bearing tests (RotasPro LP)

During bearing tests the measurement PC communicates with the PLC-control via a parallel interface. When measurement ends, the same interface carries the results to the PLC.

The sensor for structure-borne sound is connected to the fixed outer race; The rotational speed is acquired from a sensor at the spindle. Using rotationally synchronous order analysis the acoustical signals of the inner race (synchronous channel 1) and the roller and cage assembly (synchronous channel 2) are separated. The program requires the geometrical data (diameter, angle, etc.) for these computations. They are imported from the Access data base *LagerDaten.mdb*.

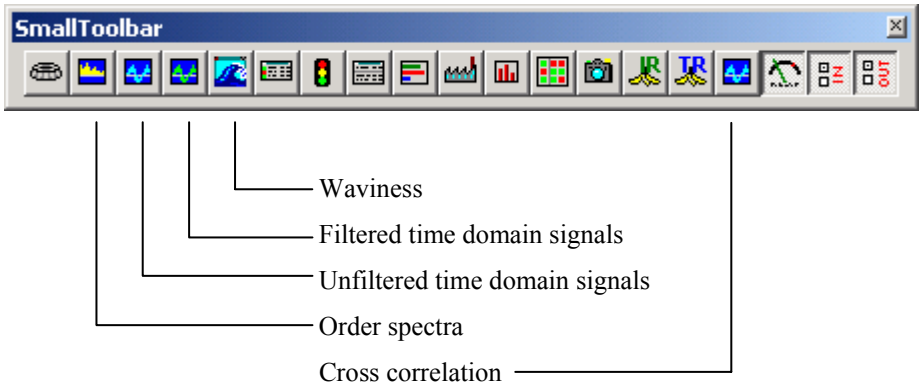
For later statistical reference the measurement reports are stored in one data base per batch. Grouped by types evaluation statistics and defect statistics are created on a per month basis. All these can be extracted and viewed with external applications (Office macros).

Information for the user: the views of RotasPro

The Scope-Views

RotasPro uses a particular type of window called "Scope", short for "oscilloscope". In principle it simulates an oscilloscope, yet it offers far more possibilities. It can be used to display curves and functions of any type, including static and varying data.

The noise signal from the current bearing can be displayed in five scopes simultaneously. For ergonomic reasons more than two scopes side by side are not recommended. You can open and close the scope windows using the following buttons on the button bar:

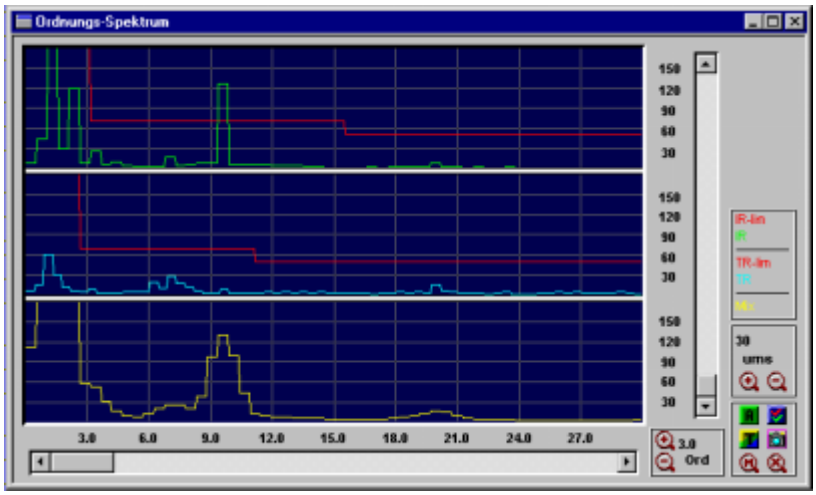


The order spectra

This scope displays the rotationally synchronous order spectrum for the inner race (IR, green), the roller and cage assembly (TR, light blue) and the mix channel (Mix, yellow) of the signal as processed by a high pass filter, in the scaling common to all Rotas applications.

Simultaneously the corresponding limit curves for the inner race (IR-lim) and roller and cage assembly (TR-lim) are displayed in red. The mix channel is not rated. Therefore no limit curve is necessary.

Waviness on the inner race or on the rollers shows up as peaks in the corresponding order spectrum. In the case of the rollers, the value can be read directly from the x-axis. This is not true for the inner race. The waviness and the orders displayed are not linearly correlated. Thus another scope (**Waviness**) has been implemented, in which the order spectrum has been scaled in such a fashion that the waviness can be read off directly.



Order spectrum of a bearing with 17 shafts on the inner race

The unfiltered time domain signal

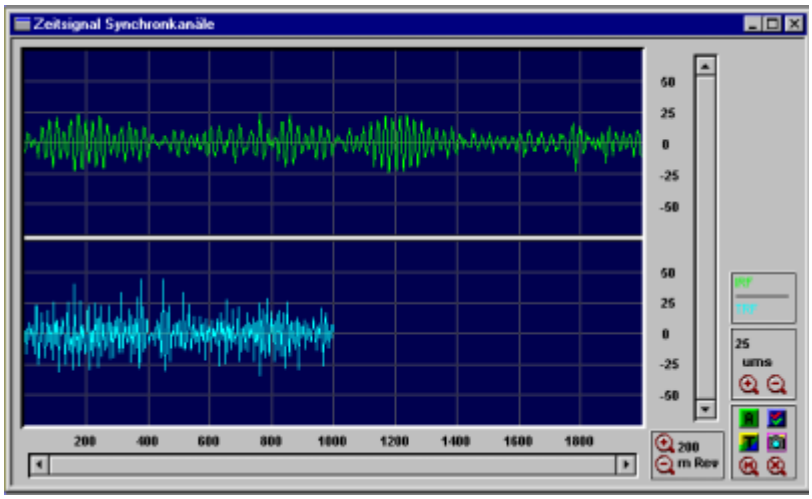
This scope shows the unfiltered time domain signal (Mix). The spindle's base frequency is easily made out.

Unfiltered time domain signal of a bearing with 17 shafts on the inner race

The filtered time domain signal

This scope shows the high-pass-filtered time domain signal for the inner race (IR, green) and the roller and cage assembly (TR, light blue). Roller and cage assembly with hit marks on the inner race or on one roller are visible as standing, tightly localised, high peaks of the corresponding time domain signal. Should the hit marks move through the scope instead of standing still, then either the geometrical parameters or the slip correction are faulty. In such an event you should check the selected type of bearing and/or recompute the slip correction.

Extreme hit marks can cross talk to the other channel. They are visible there as fast moving peaks.



Filtered time domain signal of a bearing with 17 shafts on the inner race

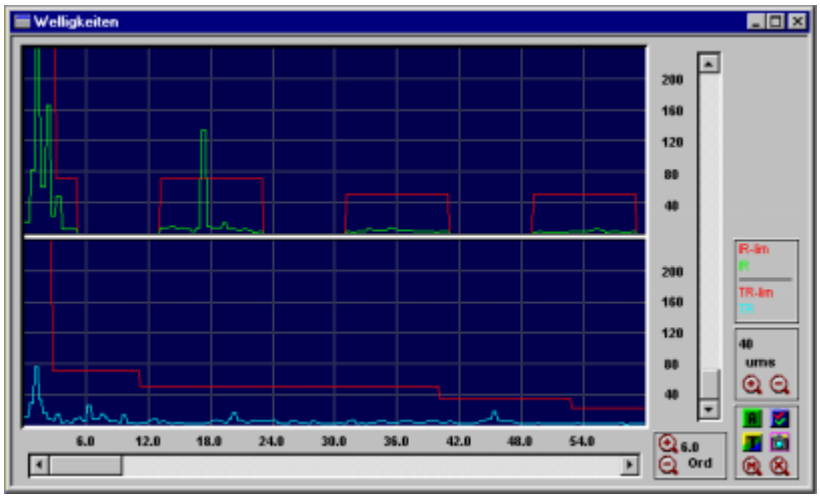
Waviness

The waviness of the bearing can be read directly from the x-axis only from the scope order spectrum for the roller and cage assembly. In the case of the inner race the correlation of the inner race order and the corresponding waviness is non-linear and depends on the bearings geometry. Therefore the scope **Waviness** shows the order spectrum for the inner race (IR, green) and the roller and cage assembly (TR, light blue) as well as their limit curves (IR-lim and TR-lim respectively, red) in such a way that the waviness for inner race and assembly can be read directly from the x-axis.

The spectra are not displayed continuously, they are displayed when measurement ends. These in particular are the spectra that are used for the rating. The display is not modified until the next measurement is completed.

The display for the inner race shows gaps in the spectrum and the limit curve at which the values are zero. The gaps are symmetrically grouped around even multiples of half the number of rollers Z. While it is possible that waviness of the inner race occurs in these intervals, no corresponding sound reaches the sensor in such a case.

The highest relative noise ratio is reached with waviness W=Z±1, slightly less dominant for W=Z±2, and so on. Here Z is the number of rollers in the bearing.



Waviness of a bearing with 17 shafts on the inner race

The cross correlation

This scope opens and closes automatically when slip correction is being computed, since that is the only context in which it shows curves at all. It then displays the cross correlation of the high-pass filtered signal of inner race or roller and cage assembly with the associated delayed signal. See the section on slip correction for more information.

Operating a scope

A scope can display more than one curve in more than one colour and you can fit the scaling to your needs. The curves can be edited using graphical or keyboard input. It is possible to insert display markings and thereby monitor certain values directly. Last but not least the curve display can be exported as a graphic so as to be accessible from other Windows applications, or sent to a printer.

The features most frequently used and therefore covered in this manual are scaling and printing.

Scaling

The view region is overlaid with a grey reticule, the lines are labelled from the left and from below. The values at the lower edge represent the x-value of the corresponding line, the values at the left edge represent the corresponding line's y-value. The units of measurement (e.g. seconds, volts) are displayed in two boxes at the lower right hand corner. The lower box belongs to the x-axis, the higher box belongs to the y-axis. For example an entry "40 mV" in the box for the y-axis indicates that the difference between values on two adjacent horizontal lines is 40 millivolts.

Each of the boxes for the units of measurement contains two buttons for adjusting the scaling: zooms in, while zooms out.

When viewing a magnified portion of the signal, the position bars at the edge of the display let you choose the part of the signal you wish to examine. When viewing several curves, the labels on the axes and the scaling hold for all displayed curves simultaneously. The position bars move all of the displayed curves.

By pushing the A-Button at the top left of the display, you can trigger automatic scaling: the scaling factors are automatically chosen in such a way that the complete curve fits the window exactly.

Pushing saves the current scaling and position, pushing reverts to the last thus saved setting. If you close and later reopen a scope window, the last saved scaling will be used, not necessarily the setting active when the window was closed.

Many curves can be normalised in two ways (e.g. "orders with regard to this channel" or "orders with regard to the spindles base frequency"). You can switch between the two in the section "scaling" of the curve selection dialog box.

The curve list

The curves displayed in a scope are listed above the unit boxes, in the right hand portion of the window, in the colours corresponding to the curve colours. When curves are displayed on top of one another in different plains, their names in the list are separated by a horizontal line.

The print popup menu

You can open up the print menu by right clicking anywhere inside the scope window except on the dark blue fields and the unit boxes. The popup menu supplies the following functionality:

print automatically: Toggle yes/no whether this scope should be printed automatically.

print now: This scope is printed immediately; no other dialog pops up.

absolute x-axis: same meaning as in the curve selection dialog.

autoscale: same meaning as the autoscale-button in the scope window.

You can also print the scope from the print menu item in the file pulldown menu. The standard printer select dialog will appear, in which you can select the printer and the paper formats. These settings remain active and will be used when you next select **print now** or when the next automatic printing takes place.

Print comment

A scope window's printout contains text comments: date, time and the names of the window and the curves are inserted automatically. For some windows the remaining comments will also be filled in automatically, for others the user can enter three text comments herself which will then appear on the printout. The texts are entered into text fields in the print comment dialog.

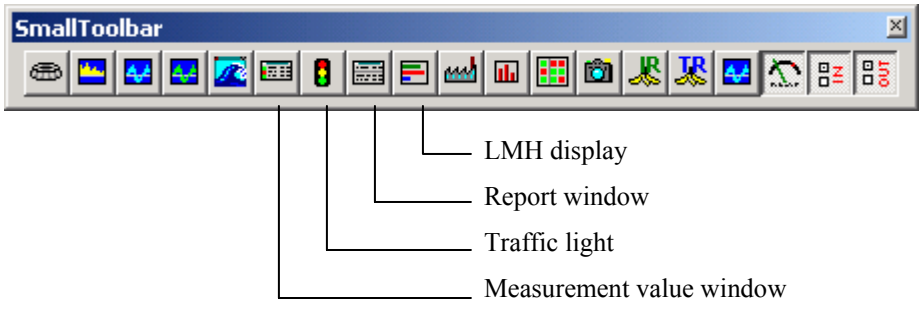
The dialog only appears if the text comments haven't been generated automatically.

Freeze display

Another button at the lower right of the scope window is the photo camera: Click this button to halt the display. You now have time to consider the data displayed and maybe print the contents of the window. By clicking the camera once more, updating of the curves resumes.

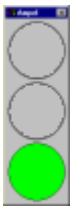
The result-views

The measurement results from the currently measured bearing are displayed on the screen in four separate views: the traffic light, the measurement value window, the report window and the LMH display. These result views, like the scope views, can be opened and closed using the buttons on the button bar.



The traffic light

The traffic light displays the overall result of the measurement. Green stands for "bearing is ok", yellow for "bearing is not ok" while a red light symbolises a system error. A system error can be the absence of the rotational speed signal or an unusually low noise level, which both could indicate a missing sensor or a defunct cable.



"ok"

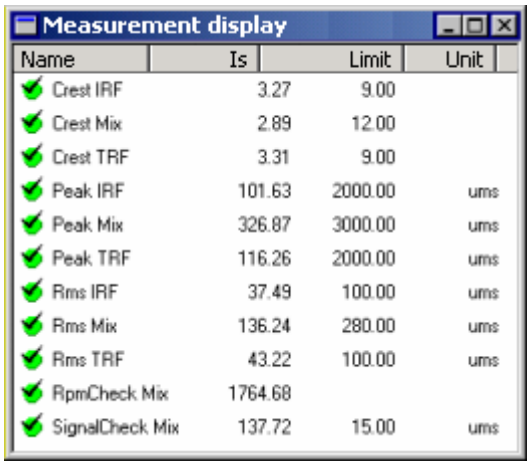
"not ok"

"system error"

The measurement value window

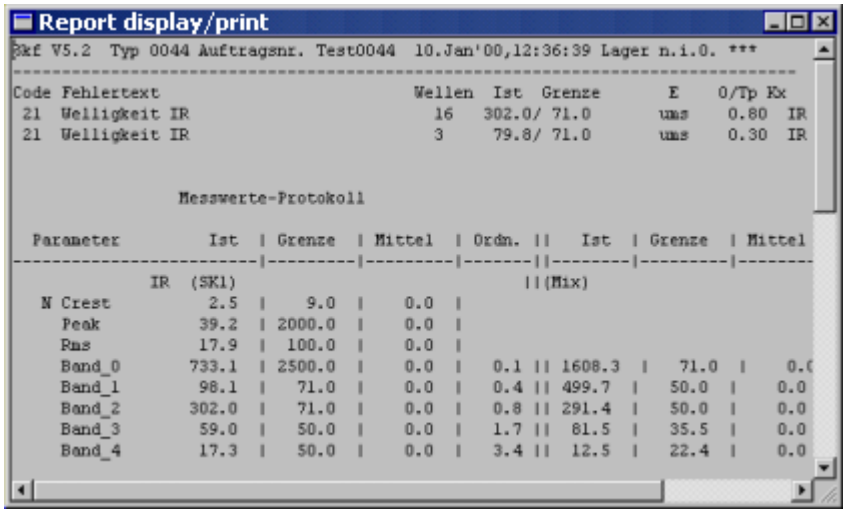
This window displays all non-spectral measurement values (e.g. Crest, RMS) that enter the rating. It includes the name of the value (including the synchronous channel from which the measurement was taken, i.e. IR, TR or Mix), the value itself (is), the limit (limit) and, where available, the unit of measurement.

The first column contains icons symbolising the result for a single value. The green icon appears when the measured value lies below the limit, the red icon indicates the limit was exceeded. The rpm check plays a role by itself, as the rotational speed is compared against an upper limit and a lower limit. Only when one of these limits is crossed does it appear in the list.



The window displays new values whenever a measurement ends. If you open the window at some other time in the measurement cycle, it will contain no values. The limits displayed pertain to the last rating made.

The report window

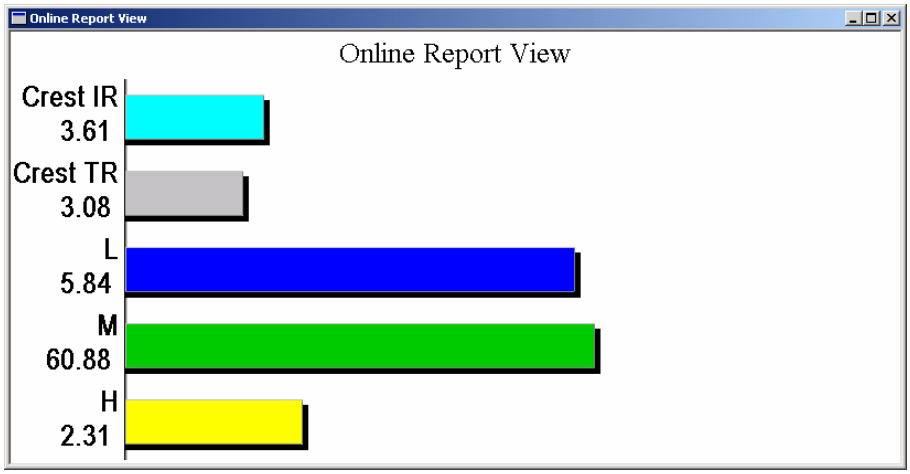

Report display/print
Bkf V5.2 Typ 0044 Auftragsnr. Test0044 10.Jan'00,12:36:39 Lager n.i.O. ***
Code Fehlertext Wellen Ist Grenze E 0/Tp Kx
21 Welligkeit IR 16 302.0/ 71.0 ums 0.80 IR
21 Welligkeit IR 3 79.8/ 71.0 ums 0.30 IR
Messwerte-Protokoll
Parameter Ist | Grenze | Mittel | Ordn. || Ist | Grenze | Mittel
IR (SK1) ||(Mix)
N Crest 2.5 | 9.0 | 0.0 |
Peak 39.2 | 2000.0 | 0.0 |
Rms 17.9 | 100.0 | 0.0 |
Band_0 733.1 | 2500.0 | 0.0 | 0.1 || 1608.3 | 71.0 | 0.0
Band_1 98.1 | 71.0 | 0.0 | 0.4 || 499.7 | 50.0 | 0.0
Band_2 302.0 | 71.0 | 0.0 | 0.8 || 291.4 | 50.0 | 0.0
Band_3 59.0 | 50.0 | 0.0 | 1.7 || 81.5 | 35.5 | 0.0
Band_4 17.3 | 50.0 | 0.0 | 3.4 || 12.5 | 22.4 | 0.0

The report window shows a summary of the measurement. The headline shows part data like type, job number, date of measurement and overall result. There follows a list of all defects located. The text should be self explanatory.

Then comes a list of measured values. Which values are to be listed is taken from the bearing data base. Typically all values from the measurement value window and all bands, including the low, medium and high bands, will be displayed.

You can print the report by right clicking anywhere in the window and selecting **print now** from the popup dialog.

The LMH display



The LMH display was designed to allow bar diagrams to be made of the low, medium and high bands. The L, M and H values are a part of the meaurement report and are also available from the report window. But the LMH display is not limited to displaying the L, M and H bands. On the contrary, it can display any subset of the values in the measurement protocol, though the more values are displayed, the less room is left for every single bar of the diagram. In addition to the bars, the corresponding numerical measurement values are included in the display.

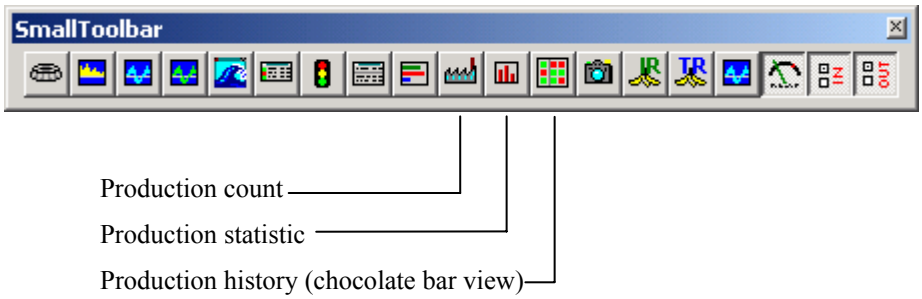
You can assign an individual colour and scaling to every bar, and the chart can be set to vertical or horizontal.

The subset of the measurement values to be displayed, as well as the bar colours and scalings, will be set up by your system administrator or in cooperation with Discom. The normal user can only call up or close the window as a whole, and change its position and size.

The online statistic views

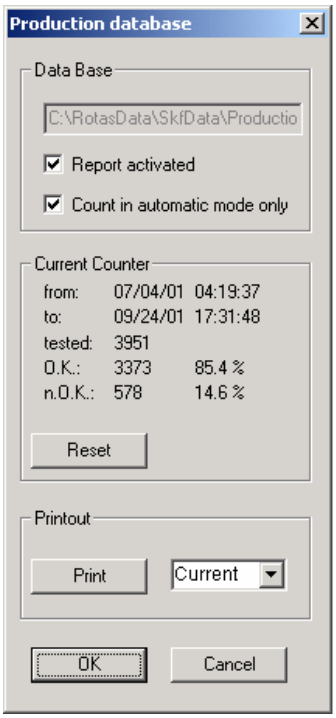
All measured values and all rated defects in the report are sorted by job number and written to a statistic data base after every measurement. Thereby a detailed offline evaluation becomes possible.

In addition RotasPro supplies three online statistical displays that allow the user to register the current state of the production at a glimpse. Like the scope and result views, the online statistical displays can be opened and closed using buttons on the button bar.



The production count

The production data base contains one production counter each for the current period, every month, and every year. The bearings ok and the bearings not ok are counted and the defects are classified by ten categories. All values are stored associated with the type of bearing.



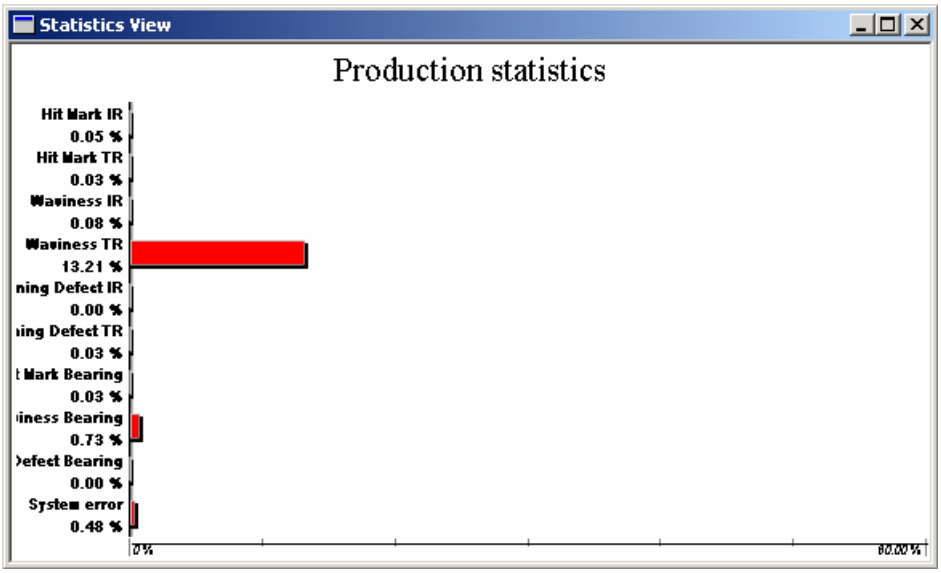
The current period is delimited by clicking the “Reset” button. Starting from one such click counting continues until the “Reset” button is clicked again. Typically you might choose the current shift or the current job number as the current period.

It is possible to configure the counters in such a way that they are automatically restarted at pre-defined times, for instance at the start of a new shift.

The counters for the current period are updated on the fly. To view the counters for another period, select that period from the list and click “Print”. The values will be entered into the report window, from where they can be printed to paper.

The production statistic

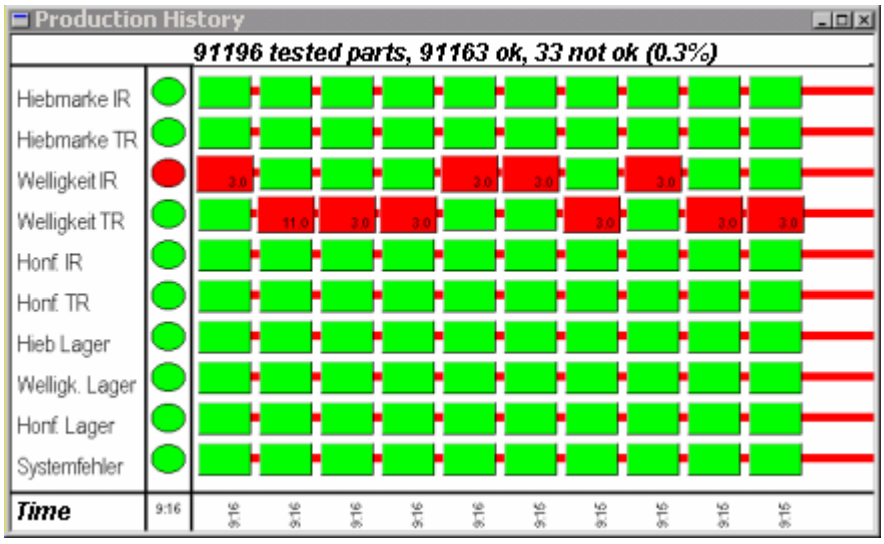
This view shows the distribution of defects over ten defect classes for the current period. Should more than one defect be detected in one bearing, only the defect of highest priority will enter the statistic in order not to distort the result.



Note that the percentages of the defect classes apply to the sum of all defects. The sum of all defect percentages is therefore 100%.

The production history (chocolate bar view)

The chocolate bar view gives the user a prompt overview of the state of the current production. The results of the latest measurements are displayed in the following way: the result of the current measurement is shown in the first column as green and red circles. A column of only green circles symbolises a measurement that was ok in all categories; a defect in one category is indicated by a single red circle on the corresponding line.



The columns of rectangular symbols (the chocolate pieces) represent past measurements. Whenever a measurement locates a defect, all chocolates move one position to the right, the rightmost column is consumed. The new measurement is inserted at the left.

Since as a rule there should be far more bearings measured ok than measured not ok, not every success is entered as an all green column to this view. Instead only every twentieth or one hundredth positive measurement is inserted into the chocolate bar view. Every all green column is a placeholder for a large number of good bearings. The exact number can be set by your system administrator.

Implications for the user:

- If all chocolates are green or if only occasional reds are sprinkled over the view, the production process is inside normal parameters.
- If all or almost all chocolates on one line are red, there is a serious flaw in the production that needs to be eliminated.

For some defect classes (waviness and hit marks) the red chocolates will contain numerical values that more closely describe the defect.

In addition to the chocolates this view displays the current production count in the headline. The values are taken directly from the production data base and are therefore identical with the values displayed there.

The error messages

MTC bit off

RotasPro communicates with the measurement stand's PLC via a parallel interface with eight outgoing bits and eight incoming bits. The connection is monitored using a control bit that is required to be high during measurement. If the bit is found to be low, the following message pops op on the screen:

In such an event you will need to check the connection with the PLC and the PLC's state.

This message cannot be removed manually. It disappears as soon as the control bit goes high. While the message is on screen no measurements will be performed, not even if the start bit is set by the PLC.

Not in setup mode

To avoid accidental switching of type, it is prohibited to change the type in any PLC mode but the setup mode. When the PLC is in the correct mode, a control bit is set. If you attempt to alter the type while the PLC is not in setup mode you will receive the following message on the screen:

If appropriate, switch to setup mode and reselect the new type.

This message can also not be removed manually. For reasons of security it remains on screen until the corresponding control bit is set by the PLC.

Unknown type

Before RotasPro can analyse a particular type, that type needs to have been entered into the bearings data base. If you select a type unknown to RotasPro or if there are problems loading the data base, the following message pops up on your screen:

In such an event you need to check your spelling and ensure that the selected type is indeed set up in the data base.

This message disappears when a known type is selected. Until then no measurements will be undertaken.

No slip correction

If no correction parameters for slip have been computed for the selected type, the following message pops up on the screen:

If appropriate insert a bearing with hit marks on the inner race and start up the computation of the slip correction for the inner race.

If the slip correction for the rollers has also not been computed, the same message will reappear, this time pertaining to the channel SK2. Insert a bearing with hit marks on one roller and start up the computation of the slip correction for the rollers.

This message also can not be removed manually. It can only be removed by completing the computation of the slip corrections.

Type selection and slip correction

Selecting a type of bearing

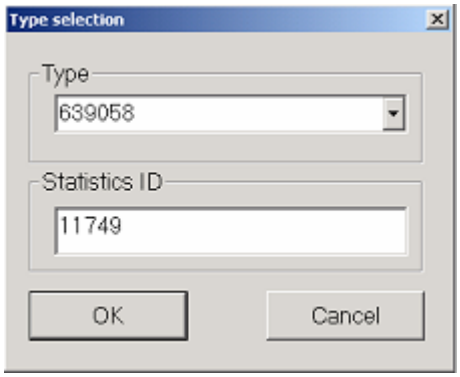
Before a type can be analysed with RotasPro, it needs to be setup in the bearings data base. The bearing parameters including the limit values are organised solely within the data base. (The parameters for slip correction form the only exception. See the next section.)

Before you can select a type that has been set up in the data base, the measurement stand's PLC needs to be switched to setup mode. You can then open the type selection dialog by clicking the first button on the button bar:

Type selection dialog

In the dialog box either select the type from the list under Type or enter it explicitly with the keyboard. Then enter the job number under Statistics ID. If no job number is available, enter an arbitrary identifier. It will be used to save the measurement values in the data base.

Click OK.



You can verify that the type has been selected correctly by checking that the type and job number are displayed in the status bar. If they are, you can safely begin with your measurements or, as may be, compute the slip correction.

When RotasPro is terminated, it stores the last type and job number entered. It reloads them at the next startup.

The two most frequent problems when selecting a new type are:

- The PLC is not in setup mode.
- The type entered was not set up in the data base.

See also the appropriate sections of this manual on related error messages.

Computing the slip correction

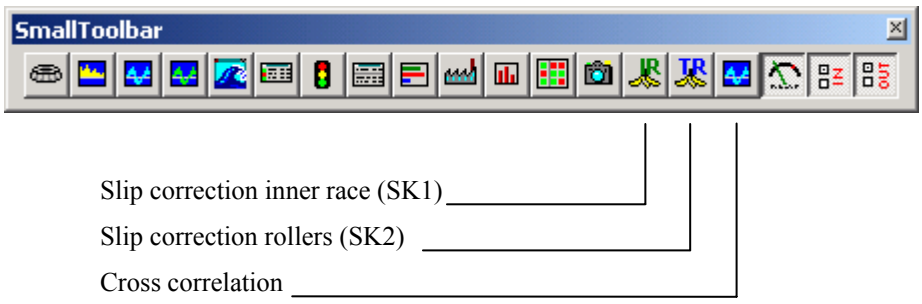
Although the values for geometry and angles of a bearing type stored in the bearings data base are stated exactly, this is not sufficient for creating rotationally synchronous sampling. Theoretical values for rotational speed of the inner race, as measured against the rollers and cage, differ from the measured values due to deviations from the geometry data and due to slip. Since geometric deviation and slip in this respect have the same effect, we will refer to the problem as slip, although we have both causes of the variation in mind.

The discrepancy is adjusted for by computing a slip correction of two sample bearings.

The two sample bearings need to be prepared in such a way that they show heavy hit marks. One should feature a hit mark on the inner race, the other on one roller.

Automatic slip computation and correction

Before the parameters for slip correction can be computed, the correct type of bearing needs to be selected within RotasPro. Then insert the two specially prepared bearings after one another and let the appropriate slip be computed.

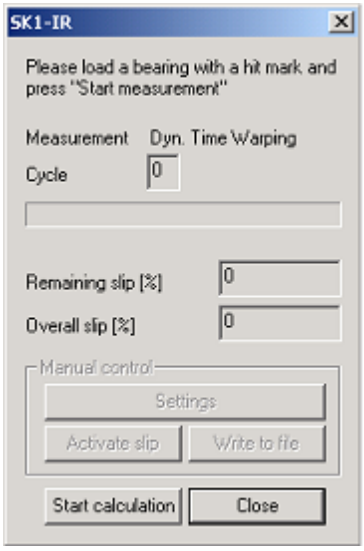


Clicking on the first of the slip correction buttons opens the dialog shown to the right and the scope cross correlation.

Click Begin calculation as soon as the bearing with the hit mark on the inner race has started rotating. Slip will be computed automatically in several iterations. The slip remaining is displayed after every step and added to the overall slip.

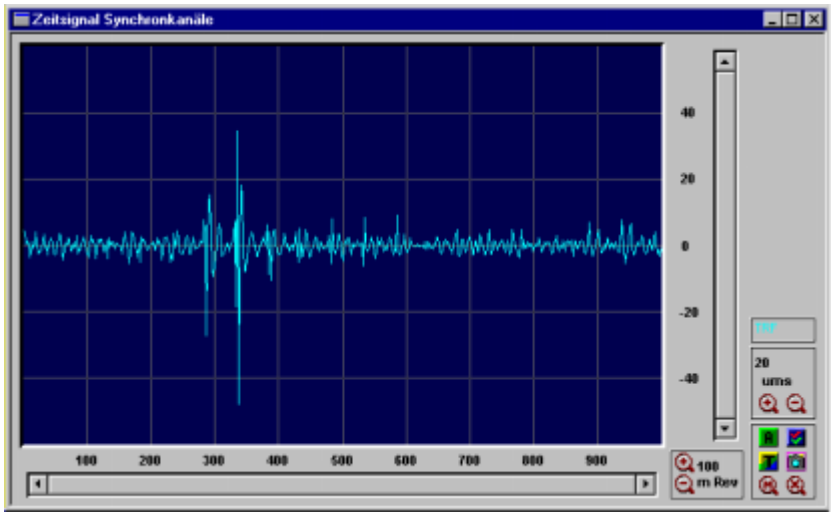
After the last cycle this dialog and the scope cross correlation will disappear automatically. The newly computed slip correction parameters are instantly stored to disk.

Proceed in the same manner to compute the slip of the rollers.

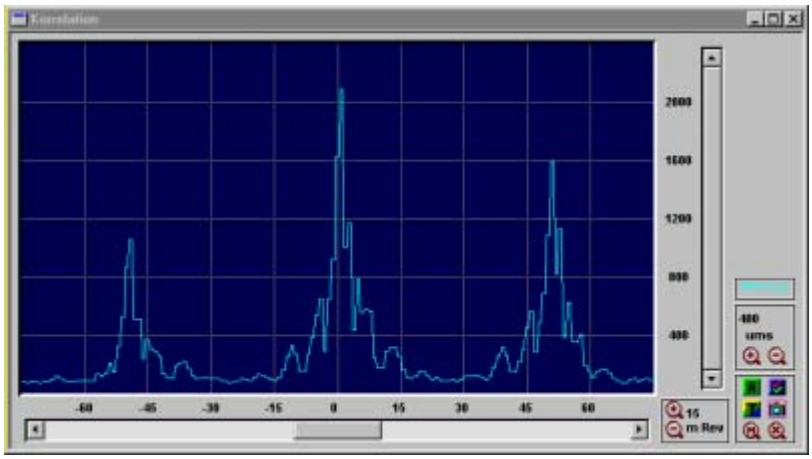


Checking the slip correction

The hit marks should show up in the time domain signal of the appropriate synchronous channel as peaks. The figure below shows the typical effect of a hit mark on one of the rollers. The peaks should stay stationary within the scope for at least one second, that is they should not move away to the left or right, or they should move very slowly. If their motion is fast, slip correction should be recomputed.



During the slip computation you should already check the results for plausibility. The full slip value typically lies below 0.2% for the inner race and below 2% for the rollers. The cross correlation is a useful tool for an exact check. Its scope is displayed while slip is being computed. When computation begins, cross correlation should have a distinct peak near zero. In the course of the iterations the peak should wander closer to zero, unless it was already there. The figure below shows a typical shot of the cross correlation window for the rollers, after slip correction has been computed successfully.



Troubleshooting — Slip correction for experts

Should the automatic slip computation lead to no results or unsatisfactory results, you should peruse the following three points in the stated order:

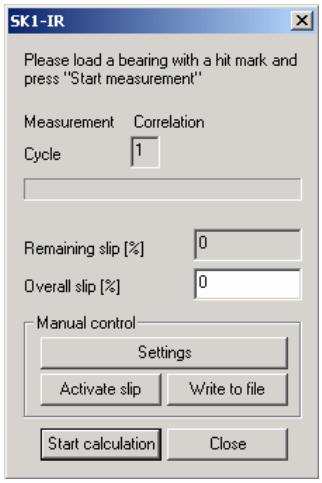
1. Check that the geometry data in the data base is correct.
2. Check the rotational speed and the quality of the hit mark.
3. Adjust the computation parameters.

Item one is self explanatory. We will discuss items two and three in detail shortly. First we shall explain manual slip correction: Even when all else fails, measurements can take place if you specify the slip values by hand.

Manual slip correction

When the slip correction dialog is first opened, by pushing the corresponding button on the button bar, all entry fields and buttons but Begin calculation and Close are inactive. In order to work manually you need to activate all fields and buttons. The simplest way to achieve this is to deliberately create an error condition during automatic slip computation. In such an event the algorithm switches to manual control.

Click Begin calculation without first inserting a bearing. After a few seconds the error message *"Error: DSP not responding. Please check that the bearing is rotating and that the speed signal is ok"* pops up. Dismiss the message by clicking Ok and the dialog will take on the appearance shown on the right. You can now insert a bearing with a hit mark and enter a slip value in the field Overall slip. By clicking Activate slip you can check the effect, by clicking Write to disk you can save the value to disk. Of course you can click Begin calculation in order to restart automatic slip computation if you like.



You should always start from an overall slip of zero. There should be a distinct peak in the cross correlation function, see also the figure in section **Checking slip correction**. The maximum need not lie at position zero yet, but it should be

close. Adjust the overall slip value iteratively while taking the following criteria into account:

Maximum in cross correlation lies to the right of zero

= Hit mark moves leftward in time domain signal

= Overall slip value is too low

And vice versa:

Maximum in cross correlation lies to the left of zero

= Hit mark moves rightward in time domain signal

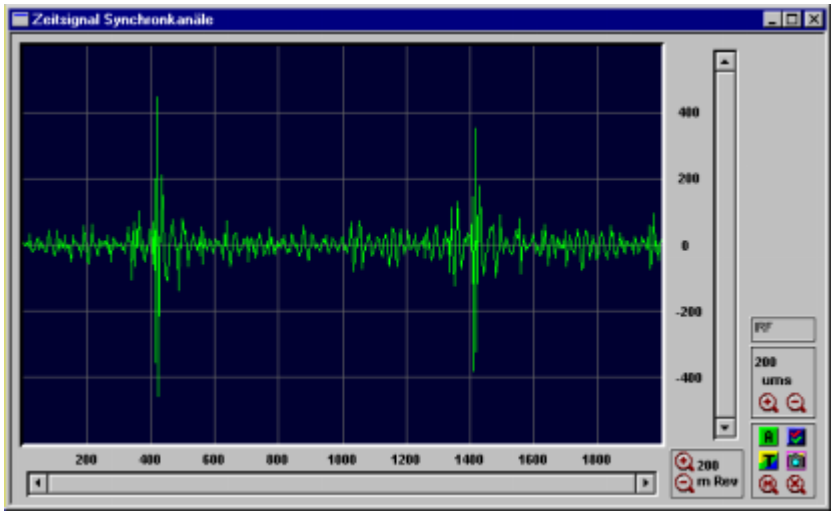
= Overall slip value is too high

Note that negative **slip** values are possible. Do not correct the **slip** value for the inner race by more than 0.03% (up or down) per iteration, for the rollers by no more than 0.3%. (These percentages should only be viewed as rules of thumb, intended to give you an idea of the orders of magnitude involved.)

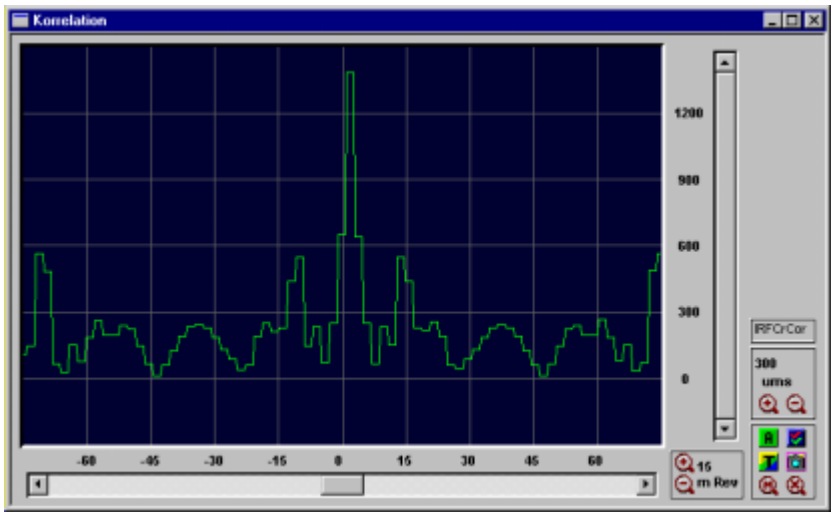
Quality of the hit mark

Enter manual slip correction as explained in the previous section. Enter zero as the value for overall slip and watch the time domain signal and the cross correlation. The hit mark should be readily visible in the time domain signal, and the cross correlation should sport one or more distinct peaks. The y-value of the peak must not be too low. Unfortunately it depends linearly on the calibration factor, so no universally valid rule can be given as to what might be considered "too low".

Find a typical example for a hit mark on the inner race below. You may compare it with the example for the marked roller above.



Example of a hit mark on the inner race as visible in the time domain signal



Example of a hit mark on the inner race as visible in cross correlation

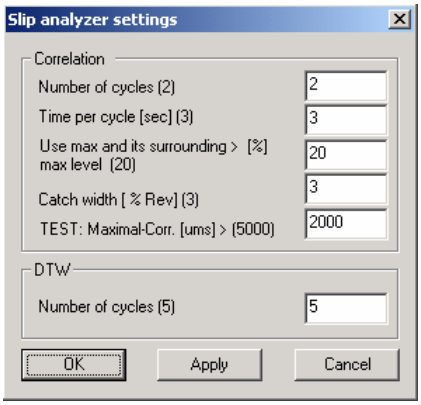
Should you see a distinct maximum in the scope cross correlation, while Rotas-Pro, engaged in automatic slip computation, nevertheless complains that no such maximum can be found, it is most likely that the threshold for accepting the maximum is too large. Find out how to set this and other parameters of slip computation in the following section.

The computation parameters

Automatic **slip** computation takes place in two steps:

1. a rough estimate from the analysis of the cross correlation.
2. a fine correction by evaluating the dynamic time warpings (DTW).

Both steps consist of several cycles; in the course of every cycle the remaining **slip** is calculated and added to the overall slip. One parameter is therefore the number of iterations in both steps. More than five correlation cycles are prohibited, while more than three usually bring no further improvement.



The number of DTW-cycles is theoretically unbounded, values between five and fifteen seem appropriate. Make sure the process as a whole doesn't take too long, as the bearings can only rotate a limited amount of time.

There are more parameters for the correlation cycles:

The measurement time per cycle: The longer the better, but three seconds are absolutely sufficient.

Use max and its surrounding > % of max level: it is sensible to use not only the position of the maximum but also the area around the maximum for computation. Distinct peaks should fall off to one fifth in their vicinity, so 20% is a good standard value. Yet it is legitimate to go as far as 50% if the situation makes this necessary. Base your decision on the cross correlation.

The Catch width indicates, how far from the origin the search for the maximum is taken. It is important that the closest distinct peak is taken, this is not

necessarily the global maximum. The catch width is given as percentage of one revolution, since the x-axis of the correlation represents rotations. The value should be of the order of three to five percent.

TEST: Maximal-Corr. [ums] >: This is a lower bound for the value of the maximum.

If the lower bound is not superseded within the catch width, or if the curve doesn't drop below the stated percentage of the maximum within the catch width, slip computation is aborted with a message indicating that no distinct peak was found. You may then want to enlarge the catch width or the “use surrounding”-value.

Working with the program menu

The menu

RotasPro uses menus sparingly. All functionality of daily usage is accessible via the button bars: the Windows symbol bar (save, print, help), the Rotas standard bar (available in two sizes) and the window layout button bar.

The button bars are called up and dismissed using the pulldown menu Toolbars, the status bar can be blended in and out in the same way, user groups and passwords are also changed using this menu, see the following sections.

The pulldown menu File offers saving program parameters (Save) and includes the three standard menu items Printer setup, Print and Print preview.

The pulldown menu Window offers three window layouts: Cascade, Tile horizontal, Tile vertical. Also you can select one of the open windows to be brought to the front.

Last but not least the pulldown menu "?" offers online help.

User groups and passwords

User groups

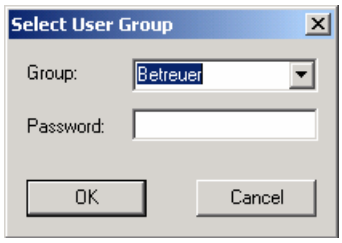
The RotasPro-system manages three user groups, namely Maschinen-Führer, Einrichter and Betreuer. The first has least permissions to make changes to the program, while the last has full access.

The Maschinen-Führer has permission to switch the type of bearing and to change the window layout. That means he can set up which views are displayed, change the window positions and the scaling of the scope-axes. He can also reset the production counter.

The Einrichter has all permissions of a Maschinen-Führer. On top of those, he has permission to compute the slip correction.

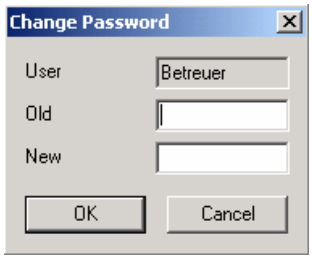
The Betreuer, this can be a DISCOM employee or a RotasPro-expert in your company, has full access. In particular he can view the system tree and thus edit all other type-independent measurement parameters, e.g. measurement period, internal and external measurement repetitions.

In order to enter a user group other than your own, select Toolbars/User group. The dialog displayed to the right will appear, using which you can select the desired user group from the list Group. In order to switch to a higher user group, you need to enter a password. It may be possible to enter one of the lower user groups without a password.



Changing a password

Change the password of the current user group using the dialog connected to Toolbars/change password. Simply enter the old password and the new password and click OK.



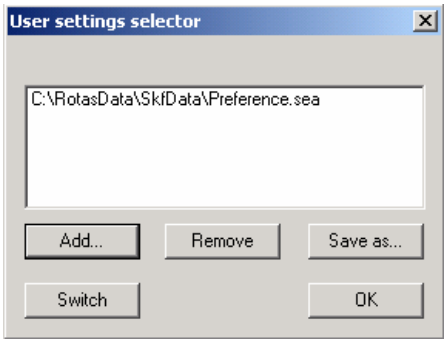
The window layout

The window layout includes all information concerning the selection of views to display, the position and size of every window and the scaling of the scope-axes. All corresponding parameters are stored in a preferences file. It is possible to create several such files and to switch between them, thus switching between the layouts stored within them.

Click the menu item Toolbars/User settings to call up this button bar.

You can switch between the layouts stored on your disk using the selection box. The result will be displayed instantaneously.

Click the button in the button bar User settings to call up the dialog displayed to the right. Here it is possible to edit the list of stored layouts by deleting entries or importing layouts available as files. You can also save your current settings under a new name.



When program execution terminates, your layout will be stored using the layout name currently active. When restarted, RotasPro will always restore the appearance it had at shutdown.